The Pharma Innovation Journal 2022; 11(11): 1396-1401

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(11): 1396-1401

www.thepharmajournal.com
Received: 10-09-2022
Accepted: 13-10-2022

Sonali Mallick
M.Sc. (Ag) in Seed Science and Technology, Department of Seed Science and Technology, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Simanta Mohanty
Assistant Seed Research Officer, Seed Technology Research, AICRP on Seed (Crops), Department of Seed Science and Technology, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Sumita Das
Ph.D. in Seed Science and Technology, Department of Seed Science and Technology, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Jayanta Kumar Beura
Technical Assistant, Seed Technology Research, AICRP on Seed (Crops), Department of Seed Science and Technology, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Godavari Bhavani Naga Jyothi
Ph.D. Scholar in Seed Science and Technology, Department of Seed Science and Technology, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Simanta Mohanty
Assistant Seed Research Officer, Seed Technology Research, AICRP on Seed (Crops), Department of Seed Science and Technology, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Effect of polymer coating on seed quality during storage of groundnut seeds

Sonali Mallick, Simanta Mohanty, Sumita Das, Jayanta Kumar Beura and Godavari Bhavani Naga Jyothi

Abstract
An investigation was undertaken in the Seed Physiology Laboratory of Department of Seed Science and Technology, College of Agriculture, OUAT, Bhubaneswar. Freshly harvested seeds of groundnut cv. ICGV-91114 (*Rabi* 2017-18 produced seed) were coated with five different polymer coatings, *viz*., Little's Polykote Yellow^{TM}, Methyl cellulose, Ethyl cellulose, Methyl vinyl acetate and Polyvinyl pyrollidone, each at two doses - 3 ml kg^{-1} seed and 4 ml kg^{-1} seed. Uncoated pods and uncoated kernels were also taken for comparison. The storage experiment was laid out in Completely Randomised Design with three replications. The coated seeds were stored under ambient conditions in cloth bags from June 2018 to December 2018. Observations on seed physiological quality and biochemical parameters were recorded at monthly intervals. The seed coating treatments were effective in reducing the rate of imbibition as well as restricting entry of moisture from the atmosphere. The % increase in seed moisture content was relatively higher in the uncoated pods and kernels compared to all the coating treatments. In all the coating treatments, seed moisture content remained below the MSCS (9% maximum) even after 6 months storage, whereas in the uncoated pods or kernels, the seed moisture content was raised above MSCS during this period. Seed germination and vigour parameters, *viz*., seed vigour indices, germination after AA and field emergence, remained high in the coated seeds even after 6 months storage under ambient conditions in cloth bags. All the coated seeds maintained germinability above MSCS (70%) even after 6 months storage. The coated seeds also maintained higher dehydrogenase and α-amylase activity, compared to the uncoated pods or kernels. There was minimum decline in oil and protein content of seeds over the storage period. Among the treatments, Methyl cellulose and Polyvinyl pyrollidone at 3 to 4 ml per kg seed were found most effective in improving the storability of groundnut seeds under ambient conditions in cloth bags. The seeds coated with these two polymers maintained germinability in the range of 74.77 to 76.47% after 6 months storage. The polymer coating technique can be used, especially for *Rabi* harvested groundnut seeds stored during the monsoon season for the next *Rabi* sowing with appreciable germination and vigour levels.

Keywords: Groundnut, polymer seed coating, seed storability

Introduction
The cultivated groundnut (*Arachis hypogaea* L.) is an important oilseed crop grown extensively in the tropical and sub-tropical regions of the world. Groundnut occupies an area of 24.7 million hectares in the world with a total production of 33 million tonnes. India occupies the first place in acreage but stands second in production. The area under groundnut in India was estimated to be 48.25 lakh hectares with a production of 99.52 lakh tonnes and productivity of 2063 kg ha^{-1} in 2019-20. In Odisha, during the same year, it was grown in an area of 29.43 thousand hectares with a production of 43.29 thousand tonnes. The overall productivity of this crop in the state is quite low (1471 kg ha^{-1}), compared to the national average (Anonymous, 2020). Groundnut is grown extensively in the state in *Rabi* season, while in *Kharif* the area is quite limited. Due to low availability and delayed supply of CS or TLS, in most of the years, farmers are compelled to use their own saved seed, which is of relatively inferior quality as compared to the quality seeds purchased from the market. Moreover, poor storability of this 'high protein-high oil' containing seed under 'high humidity-high temperature' conditions means that, on most occasions, the seed sown is of low germination potential and vigour. Due to use of low quality seeds, the performance of the crop is even more affected when adverse weather conditions prevail during the sowing and crop growth season.
Groundnut seed is a poor storer and loses viability and vigour rapidly in storage. Seed deterioration is an irreversible and inexorable process but the rate of deterioration could be

slowed down either by storing the seeds under controlled conditions or by imposing polymer film coating along with seed treatment chemicals. As controlled condition is highly expensive, seed coating remains an effective alternative approach to maintain seed quality. Seed coating with polymers is one of the most economical approaches for improving seed storability and field performance. The polymer coat acts as physical barrier against moisture entry and has been reported to reduce the leaching of inhibitors and restrict oxygen diffusion to the embryo (Kumar *et al*., 2014) [8]. Polymer coating is simple to apply, diffuses rapidly in soil and is non-toxic to the seed during germination (Reddy *et al*., 2019) [13]. Polymer seed coating can help in accurate application of chemicals, reducing chemical wastage and ensuring dust-free handling. Hence, the present investigation was undertaken to study the effect of a few coating treatments on enhancement of seed quality and improvement of subsequent performance of groundnut during storage.

Materials and Methods

The experiment was conducted in the Seed Physiology Laboratory of Department of Seed Science and Technology, College of Agriculture, OUAT, Bhubaneswar. Freshly harvested seed of groundnut cv. ICGV-91114 (*Rabi* 2017-18 produced seed) was collected from seed producer. Assessment of germinability and vigour of seeds was done prior to coating of the seeds. The experiment was laid out in Completely Randomised Design with three replications and twelve treatments, *viz.*, uncoated pod (T_1), uncoated kernel (T_2), Little's Polykote Yellow™ @ 3 ml kg^{-1} seed (T_3), Little's Polykote Yellow™ @ 4 ml kg^{-1} seed (T_4), Methyl Cellulose @ 3 ml kg^{-1}seed (T_5), Methyl Cellulose @ 4 ml kg^{-1} seed (T_6), Ethyl Cellulose@ 3ml kg^{-1} seed (T_7), Ethyl Cellulose@ 4 ml kg^{-1} seed (T_8), Methyl vinyl acetate @ 3 ml kg^{-1} seed (T_9), Methyl vinyl acetate @ 4 ml kg^{-1} seed (T_{10}), Polyvinyl Pyrollidone @ 3 ml kg^{-1} seed (T_{11}), Polyvinyl Pyrollidone @ 3 ml kg^{-1} seed (T_{12}). After coating, the seeds were dried to original moisture content and stored under ambient conditions in cloth bags from June 2018 to December 2018. Regular observations on various seed physiological quality parameters were recorded at monthly intervals. Changes in biochemical parameters of the seeds were also estimated.

Results and Discussion

There was gradual increase in moisture content over 6 months of storage under ambient condition in cloth bags. The % increase in moisture content was relatively higher in the uncoated pods and kernels compared to all the coating treatments. After 6 months of storage, the moisture content of the coated seeds of various treatments ranged from 8.36 to 8.59%, while it was 9.17% in the uncoated pods and 9.52% in the uncoated kernels.

Seed germination (%) declined progressively over a period of storage due to seed coating polymers. The % decrease in germination was relatively higher in the uncoated pods and kernels as compared to all the coated kernels. Among the different treatments, the seeds coated with Methyl cellulose @ 4 ml kg^{-1} seed recorded significantly higher seed germination (76.40%) whereas, lowest germination was recorded in uncoated kernels (67.43%) after 6 months of storage. Chikkanna *et al*. (2000) [4] reported in groundnut seed coated with the hydrophilic polymer @ 20 g per kg of seed increased the germination % over control. Dadlani and Vashisht (2006) [5] studied the storability of soybean seed by polymer coating with polykote @ 4 ml per kg of seed stored in superbag recorded highest germination (88.0%) as compared to 70% in control. Soybean seeds treated with black and red polykote recorded significant increase in germination % over control (Keshavulu and Krishnaswamy, 2005) [7]. Seed vigour indices (SVI-I and SVI-II) of groundnut seeds decreased gradually as the storage period increased in different seed treatments under ambient conditions in cloth bags. After 6 months of storage, significantly higher seed vigour indices (2596.6 and 2.24, respectively) were recorded in the polymer coating treatments as compared to uncoated pods (1949.2 and 1.88, respectively). Venkatesh *et al.* (2018) [17] reported that soybean seeds treated with different fungicides along with polymer (5 ml kg^{-1}) recorded significantly higher seedling vigour index-I (1524) and seed vigour index-II (7747) at the end of nine months of storage period as compared to control.

Seed infection (%) increased with increase in storage period in uncoated control and seed coating with polymers, though the rate of increase was much higher in the Control. Among the treatments, both Polyvinyl pyrollidone and Methyl cellulose @ 4 ml kg^{-1} of seed recorded lowest % of infected seed (1.20%) after six months of storage, while the maximum seed borne infection was (10.71%) in uncoated pods. Goswami *et al.* (2017) [6] investigated that out of all chemical treatments, flowable thiram @ 2.4 ml kg^{-1} (T_2) and Polymer + Vitavax 200 @ 2 g kg^{-1} seed (T_5) exhibited minimum per cent seed infection of *Aspergillus flavus* for longer storage of soybean seeds under ambient storage. Similarly, the seed infestation (%) increased with increase in storage period in all treatment combinations. Among the treatments, Polyvinyl pyrollidone @ 4 ml kg^{-1} of seeds recorded minimum seed infestation of 0.80%, while maximum seed infestation was (2.50%) in uncoated pods.

Among all the treatments, the leachate conductivity increased gradually with increase in storage period under ambient condition in cloth bags. At the end of six months storage, seeds coated with Polyvinyl pyrollidone @ 3 ml kg^{-1} seed recorded minimum EC of seed leachates (0.126 dS m^{-1}), as compared to uncoated pods or kernels (0.157 dS m^{-1} and 0.202 dS m^{-1}) stored in cloth bag. Seeds treated with polymer have less electrical conductivity of seed leachates as compared to untreated seeds due to maintenance of cell membrane integrity. It might be due to impervious nature of polykote for the internal constituents. Similar, findings were reported by Vasundhara and Bommegouda (1999) in groundnut and Patil *et al*. (2004) [11] in pearl millet, Baig (2005) in soybean and Kunkur *et al*. (2007) [9] in cotton. The total dehydrogenase activity decreased with increase in storage period. This enzyme is essential for protein synthesis and energy production during germination. Among the treatments, Methyl cellulose @ 3 ml kg^{-1} seed recorded the highest dehydrogenase activity (0.644 mg g^{-1} FW) compared to the lowest in uncoated pods (0.129 mg g^{-1} FW). According to Siddaraju (2015) [14], seeds treated with polykote @ 3 ml kg^{-1} + vitavax 200 @ 2 g kg^{-1} seeds recorded maximum total dehydrogenase activity (1.509 mg g^{-1} FW), at the end of 8 month storage. α-amylase activity decreased as the storage period progressed. At the end of 6 months, seed coated with Methyl cellulose @ 3 ml kg^{-1} seed showed significantly higher α-amylase activity (0.295 units g^{-1} FW) as compared to uncoated pods or kernels (0.113 and 0.116 units g^{-1} FW, respectively) and other coating treatments. Thobunluepop *et* *al.* (2009) [16] reported that the seeds were coated by biological polymers significantly affected the rice seed storability and the associated biochemical deterioration after 12 months storage over control. Loss of viability of seeds has been correlated to enzymatic activity. Abdul-Baki and Anderson (1973) [1] reported that the activity of respiratory enzyme and α-amylase associated with the degradation of organelles membranes, nucleoproteins, etc.

There was gradual decrease in protein content in the seed coating treatments under ambient conditions in cloth bags. However, % decrease in protein content was relatively higher in the uncoated pods and kernels, as compared to all the coating treatments. At the end of six months of storage period, seed treatments, especially Methyl cellulose @ 4 ml kg^{-1} seed (25.52%), were found effective for improving the protein content over uncoated pods and kernels (25.22% and 25.21%, respectively). According to Siddaraju (2015) [14], seeds treated with polykote @ 3 ml kg^{-1} + vitavax 200 @ 2 g kg^{-1} seeds recorded maximum total soluble protein content (10.062%) than untreated seeds at the end of 8 months storage. The oil content declined progressively as the storage period advanced under ambient condition in cloth bags. In different coating treatments, % decrease in oil content was relatively lower as compared to uncoated pods or kernels. Seed treatment with Ethyl cellulose @ 4 ml kg^{-1} seed recorded the highest oil content (47.69%) at the end of seed storage period as compared to uncoated pods or kernels (47.27% and 47.06%). Similar results were also noticed by Ramamoorthy and Karivaratharaju (1986) [12] in groundnut and Sisman (2005) [15] in sunflower. In oilseed crops auto-oxidation of lipids and increase of free fatty acids during storage period are the main reasons for rapid deterioration of the oilseeds (Martini *et al*., 2005) [10].

Conclusion

Groundnut cultivation in the state of Odisha suffers mainly due to non-availability of quality seeds for the *Rabi* crop, as the seeds of previous *Rabi* season are unable to maintain high germinability and vigour due to high humidity and high temperature during the monsoon season. The availability of the *Kharif* produced seeds is delayed, for which the farmers are compelled to use relatively poor quality farmers' saved seed for raising their crop. The present investigation was designed to find a suitable seed coating technique for improving storability of *Rabi* harvested groundnut seeds for the next *Rabi* sowing. From the results of the experiment, it can be concluded that synthetic polymers such as Methyl cellulose and Polyvinyl pyrollidone at 3 to 4 ml per kg seed can be used for coating groundnut kernels for effectively improving their storability. The seed coatings were useful in reducing the rate of imbibition, restricting entry of moisture from the atmosphere and maintaining germinability above MSCS even after 6 months storage. Moreover, there was minimum increase in seed infection, seed infestation, seed leachate conductivity and minimum decrease in dehydrogenase and α-amylase activity, oil and protein contents, due to the polymer coatings, as against the uncoated pods or kernels.

Table 1: Changes in seed moisture content, germination and vigour of polymer coated groundnut seeds stored for 6 months under ambient conditions

Treatments	Seed moisture content (%)		Seed germination (%)		Seed vigour index-I		Seed vigour index-II	
	After coating	After 6 months	After coating*	After 6 months**	After coating	After 6 months	After coating	After 6 months
T_1 : Uncoated pods	8.14	9.17	91.00 (9.54)	67.87 (55.47)	2943.4	1949.2	2.82	1.88
T_2 : Uncoated kernels	8.21	9.52	93.00 (9.64)	67.43 (55.24)	3133.8	1959.5	2.52	1.56
T_3: Little's Polykote™ 3ml kg^{-1} seed	8.18	8.58	93.97 (9.69)	75.17 (60.12)	3176.4	2422.4	1.97	1.50
T_4 : Little's Polykote™ 4 ml kg^{-1} seed	8.09	8.44	95.00 (9.75)	76.40 (60.94)	3169.9	2445.1	2.00	1.53
T_5 : Methyl cellulose @ 3 ml kg^{-1} seed	8.18	8.53	93.23 (9.66)	74.77 (59.85)	3029.7	2329.9	2.61	2.02
T_6 : Methyl cellulose @ 4 ml kg^{-1} seed	8.13	8.37	94.03 (9.70)	76.47 (60.98)	3076.2	2428.1	1.97	1.56
T_7 : Ethyl cellulose @ 3 ml kg^{-1} seed	8.12	8.52	92.00 (9.59)	73.53 (59.05)	2915.3	2221.5	1.47	1.10
T_8 : Ethyl cellulose @ 4 ml kg^{-1} seed	8.15	8.50	91.00 (9.54)	73.17 (58.80)	2886.5	2225.8	2.91	2.24
T_9 : Methyl vinyl acetate @ 3 ml kg^{-1} seed	8.15	8.50	93.03 (9.65)	74.80 (59.87)	2730.0	2104.9	2.33	1.80
T_{10} : Methyl vinyl acetate @ 4 ml kg^{-1} seed	8.29	8.59	93.00 (9.64)	75.20 (60.13)	2938.0	2292.2	1.77	1.35
T_{11} : Polyvinyl pyrollidone @ 3 ml kg^{-1} seed	8.19	8.54	95.03 (9.75)	76.40 (60.94)	2963.9	2285.3	2.85	2.19
T_{12} : Polyvinyl pyrollidone @ 4 ml kg^{-1} seed	8.11	8.36	93.03 (9.65)	75.67 (60.45)	3289.6	2596.6	2.33	1.84
S.E.m(±)	0.107	0.122	0.064	0.587	81.18	54.19	0.061	0.046
$C.D._{0.05}$	NS	0.357	NS	1.712	236.94	158.18	0.179	0.133

* Figures in parentheses are square root transformed values ** Figures in the parentheses are arc sine transformed values.

Table 2: Changes in seed infection and infestation (%) of polymer coated groundnut seeds stored for 6 months under ambient conditions

Treatments	Seed infection (%)		Seed infestation (%)	
	After coating*	After 6 months*	After coating*	After 6 months*
T_1 : Uncoated pods	2.40 (1.55)	10.71 (3.27)	1.20 (1.09)	7.14 (2.67)
T_2 : Uncoated kernels	1.19 (1.09)	6.92 (2.63)	0.59 (0.77)	4.62 (2.14)
T_3: Little's Polykote™ 3ml kg^{-1} seed	1.20 (1.09)	2.85 (1.69)	0.60 (0.77)	1.90 (1.38)
T_4 : Little's Polykote™ 4 ml kg^{-1} seed	0.60 (0.77)	1.38 (1.17)	0.30 (0.55)	0.92 (0.96)
T_5 : Methyl cellulose @ 3 ml kg^{-1} seed	1.20 (1.09)	2.70 (1.64)	0.60 (0.77)	1.80 (1.34)
T_6 : Methyl cellulose @ 4 ml kg^{-1} seed	0.60 (0.77)	1.20 (1.09)	0.30 (0.55)	0.80 (0.89)
T_7 : Ethyl cellulose @ 3 ml kg^{-1} seed	1.20 (1.10)	2.85 (1.69)	0.60 (0.77)	1.90 (1.38)
T_8 : Ethyl cellulose @ 4 ml kg^{-1} seed	2.40 (1.55)	5.40 (2.32)	1.20 (1.09)	3.60 (1.90)
T_9 : Methyl vinyl acetate @ 3 ml kg^{-1} seed	1.18 (1.09)	2.70 (1.64)	0.59 (0.77)	1.80 (1.34)

T_{10} : Methyl vinyl acetate @ 4 ml kg^{-1} seed	1.22 (1.10)	2.55 (1.60)	0.61 (0.78)	1.70 (1.30)
T_{11} : Polyvinyl pyrollidone @ 3 ml kg^{-1} seed	0.60 (0.77)	1.38 (1.17)	0.30 (0.55)	0.92 (0.96)
T_{12} : Polyvinyl pyrollidone @ 4 ml kg^{-1} seed	0.60 (0.77)	1.20 (1.09)	0.30 (0.55)	0.80 (0.89)
S.E.m(±)	0.029	0.055	0.021	0.045
C.D.$_{0.05}$	0.084	0.162	0.060	0.132

* Figures in parentheses are square root transformed values

Table 3: Changes in biochemical parameters of polymer coated groundnut seeds stored for 6 months under ambient conditions

Treatments	Electrical conductivity (EC) of seed leachate (dS m^{-1})		Dehydrogenase activity (mg g^{-1} FW)		α-amylase activity (units g^{-1} FW)	
	After coating	After 6 months	After coating	After 6 months	After coating	After 6 months
T_1 : Uncoated pods	0.139	0.157	0.145	0.129	0.127	0.113
T_2 : Uncoated kernels	0.174	0.202	0.238	0.205	0.135	0.116
T_3: Little's Polykote^{TM} 3ml kg^{-1} seed	0.216	0.226	0.358	0.342	0.126	0.120
T_4 : Little's Polykote^{TM} 4 ml kg^{-1} seed	0.135	0.141	0.486	0.466	0.105	0.101
T_5 : Methyl cellulose @ 3 ml kg^{-1} seed	0.152	0.158	0.672	0.644	0.308	0.295
T_6 : Methyl cellulose @ 4 ml kg^{-1} seed	0.193	0.198	0.459	0.445	0.194	0.188
T_7 : Ethyl cellulose @ 3 ml kg^{-1} seed	0.150	0.157	0.385	0.367	0.255	0.243
T_8 : Ethyl cellulose @ 4 ml kg^{-1} seed	0.173	0.180	0.376	0.361	0.283	0.272
T_9 : Methyl vinyl acetate @ 3 ml kg^{-1} seed	0.286	0.298	0.392	0.376	0.123	0.118
T_{10} : Methyl vinyl acetate @ 4 ml kg^{-1} seed	0.149	0.154	0.387	0.373	0.113	0.109
T_{11} : Polyvinyl pyrollidone @ 3 ml kg^{-1} seed	0.121	0.126	0.285	0.273	0.116	0.111
T_{12} : Polyvinyl pyrollidone @ 4 ml kg^{-1} seed	0.126	0.130	0.299	0.290	0.124	0.120
S.E.m(±)	0.0022	0.0026	0.0038	0.0034	0.0020	0.0018
C.D.$_{0.05}$	0.0065	0.0075	0.0110	0.0100	0.0058	0.0051

Table 4: Changes in chemical composition of polymer coated groundnut seedsstored for 6 months under ambient conditions

Treatments	Oil content (%)		Protein content (%)	
	After coating	After 6 months	After coating	After 6 months
T_1 : Uncoated pods	47.84	47.27	25.52	25.22
T_2 : Uncoated kernels	47.77	47.06	25.59	25.21
T_3: Little's Polykote^{TM} 3ml kg^{-1} seed	47.88	47.65	25.39	25.27
T_4 : Little's Polykote^{TM} 4 ml kg^{-1} seed	47.56	47.36	25.51	25.41
T_5 : Methyl cellulose @ 3 ml kg^{-1} seed	47.72	47.52	25.48	25.37
T_6 : Methyl cellulose @ 4 ml kg^{-1} seed	47.59	47.45	25.59	25.52
T_7 : Ethyl cellulose @ 3 ml kg^{-1} seed	47.81	47.58	25.46	25.34
T_8 : Ethyl cellulose @ 4 ml kg^{-1} seed	47.89	47.69	25.61	25.50
T_9 : Methyl vinyl acetate @ 3 ml kg^{-1} seed	47.76	47.56	25.27	25.17
T_{10} : Methyl vinyl acetate @ 4 ml kg^{-1} seed	47.68	47.51	25.52	25.43
T_{11} : Polyvinyl pyrollidone @ 3 ml kg^{-1} seed	47.73	47.53	25.47	25.36
T_{12} : Polyvinyl pyrollidone @ 4 ml kg^{-1} seed	47.69	47.56	25.43	25.36
S.E.m(±)	0.655	0.649	0.333	0.329
C.D.$_{0.05}$	NS	NS	NS	NS

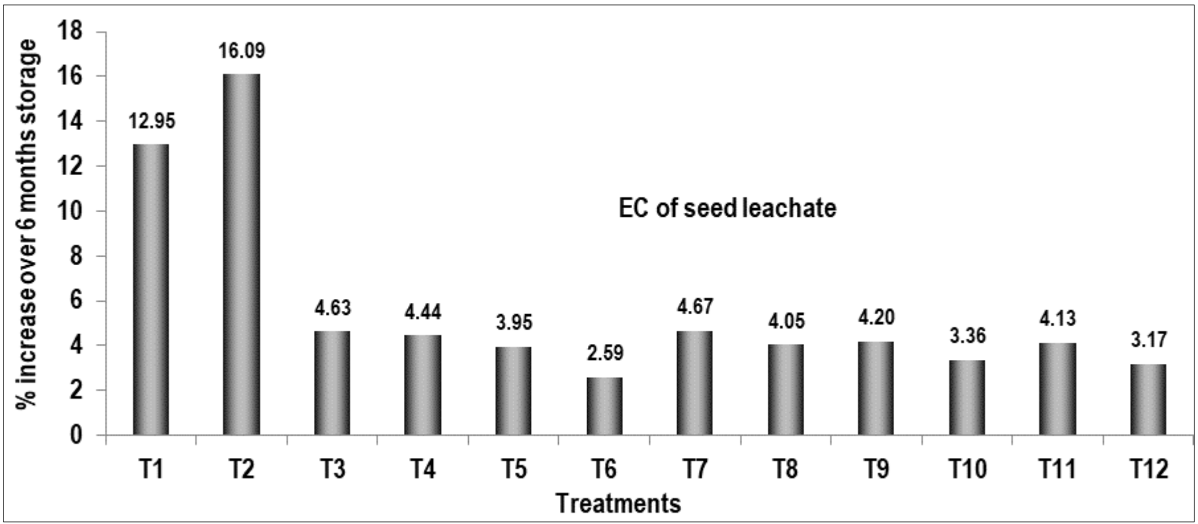

Fig 1: % increase in leachate conductivity of polymer coated seeds over 6 months storage as against the initial value

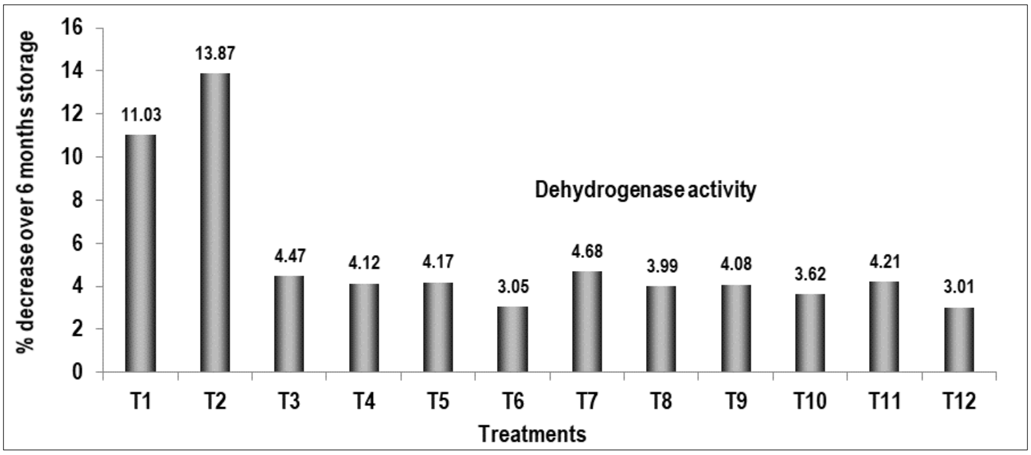

Fig 2: % decrease in dehydrogenase activity of polymer coated seeds over 6 months storage as against the initial value

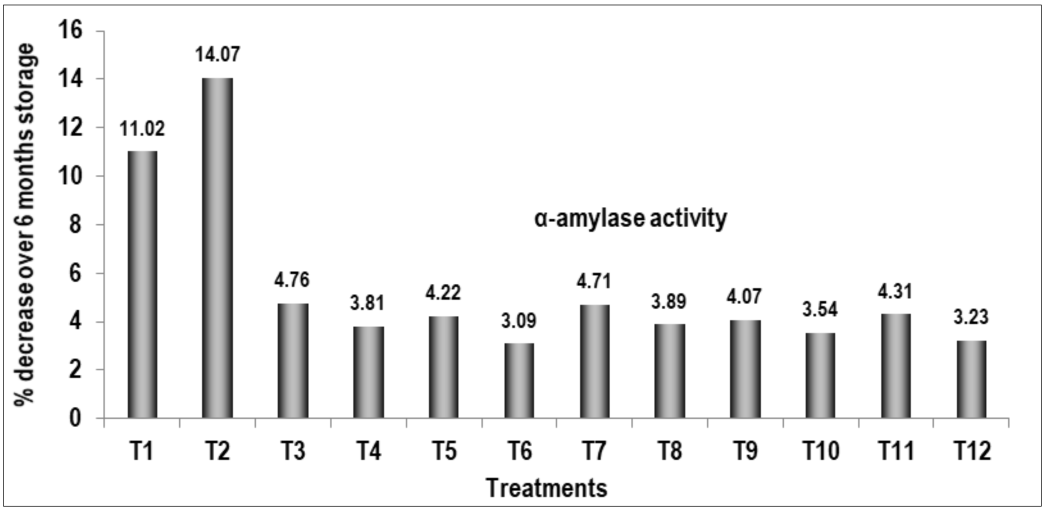

Fig 3: % decrease in α-amylase activity of polymer coated seeds over 6 months storage as against the initial value

References

1. Abdul-Baki AA, Anderson JP. Vigour deterioration in soybean by multiplecriteria. Crop Science. 1973;13:630-637.
2. Anonymous, 2020. https://eands.dacnet.nic.in, Directorate of Economics and Statistics, Department of Agriculture and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India. Accessed on 20th December 2021.
3. Baig I. Effect of grading methods, fungicides and polymer coating on storability of soybean [*Glycine max* (L.) Meril], M. Sc. (Agri.) Thesis, Univ. Agric. Sci., Dharwad (India), 2.
4. Chikkanna CS, Timmegouda Ramesh R. Hydrophilic polymer seed treatment on seed quality and yield in finger millet, cowpea and groundnut. Seeds and Farms. 2000;85:39-45.
5. Dadlani M, Vashisht V. Prolonged storability of soybean seed. Proc. of XII Nat. Seed Sem. at ANGRAU, Hyderabad, 2006.
6. Goswami AP, Vishunavat K, Mohan C, Ravi S. Effect of seed coating wheat (*Triticum aestivum* L.), International Journal of Multidisciplinary Research and Development storage periods and storage containers on soybean (*Glycine max* (L.) Merrill) seed quality under ambient conditions. Journal of Applied and Natural Science. 2017;9(1):598–602.
7. Keshavulu K, Krishnasamy V. Effect of seed colouring on seed quality and bruchid damage in soybean. Seed Research. 2005;33:208-210.
8. Kumar TP, Asha AM, Maruthi JB, Vishwanath K. Influence of seed treatment chemicals and containers on seed quality of marigold during storage. The Bioscan. 2014;9:937-942.
9. Kunkur V, Hunje R, Biradarpatil NK, Vyakarnahal BS. Effect of seed coating with polymer, fungicide and insecticide on seed quality in cotton during storage. Karnataka Journal of Agricultural Sciences. 2007;20:137-139.
10. Martini S, Anon MS. Storage of sunflower seed variation on the wax content of the oil. European Journal of Lipid Science and Technology. 2005;107:74-79.
11. Patil SK, Janpure SV, Shelar VR, Dumbre AD. Efficacy of insecticides and fungicides on seed germination, insect infestation and seed mycoflora on pearlmillet during storage. Seed Research. 2004;32:189-192.
12. Ramamoorthy K, Karivaratharaju TV. Storability and biochemical compositions of groundnut seed as influenced by packaging and seed treatment. Indian Agriculture. 1986;30:101-106.
13. Reddy BP, Bara BM, Krishina RY. Effect of Polymer Seed Coating and Seed Treatment on Seed Quality Parameters and Yield Attributing Characters of Hybrid Maize (*Zea mays* L.). International Journal of Current

Microbiology and Applied Sciences. 2019;8:1175-1182.
14. Siddaraju R, Narayanaswamy S, Ramanappa TM. Study on the effect of seed coating with synthetic polymer and seed treatment chemicals on physiological changes and seed infestation of maize hybrid Hema (*Zea mays* L.) during seed storage. Mysore Journal of Agricultural Sciences. 2015;49:467-477.
15. Sisman CB. Quality losses in temporary sunflower stores and influences of storage conditions on quality losses during storage. Journal of Central European Agriculture. 2005;6:143-150.
16. Thobunluepop, Chitbanchong, Pawelzik E, Vearasilp. Physiological and Biochemical Evaluation of Rice Seed Storability with Different Seed Coating Techniques, International Journal of Agricultural Research. 2009;4:169-184.
17. Venkatesh B, Basavegowda, Vasudevan SN, Doddagoudar SR, Sunkad G, Konda CR. Effect of seed coating with fungicides along with polymer on seed storability of soybean (*Glycine max* L. Merril). International Journal of Chemical Studies. 2018;6:598-602.